

# ISLAND FOX RECOVERY RECOMMENDATION FROM THE CHANNEL ISLAND FOX RECOVERY COORDINATION GROUP

## TECHNICAL ANALYSIS REQUEST TITLE AND NUMBER IDENTIFICATION

**Technical Analysis 3.4:** Develop management and husbandry plans for each subspecies, taking into account studbook data, and results from research into best husbandry practices (pen size, social structure, mate choice, etc). The focus for research and management for each captive population will depend on the size and stability of that subspecies' wild and captive populations.

*Relates to: Santa Rosa, Santa Cruz, San Miguel  
Technical Expertise Group involved: CP*

**DATE:** 12 April 2005

## EXECUTIVE SUMMARY:

We thank the Task Force for its thorough analysis of existing knowledge of the captive management and breeding protocols, and its suggested priorities for the research required both to increase productivity and to prepare and monitor captive-bred island foxes before and after release into the wild.

The analysis revealed just how much we know about island fox biology, but also how large are the gaps in our knowledge. Recent data suggest that captive-born island foxes in island breeding facilities are reproducing very poorly, suggesting that production for release will be seriously compromised unless reproductive success improves dramatically. As a result, we recommend that research on the environmental and social correlates of captive breeding success and on the development of mate choice be given the highest priority. Additionally, we recommend several activities to enhance communication among caretakers of island foxes so that new (and existing) information concerning fox biology and management will be disseminated rapidly throughout the island fox community. Finally, we have responded to the suggestion for a research program to provide information for preparing foxes for eventual release by requesting a Task Force (3.5) to develop minimum standardized pre-release and post-release management and monitoring protocols for all listed subspecies of island foxes and to identify priority research that will permit the comparison of methodologies to determine the most successful pre- and post-release management.

## BACKGROUND:

Island foxes were brought into captivity in 1998-1999 as a temporary solution to their rapid and dramatic decline, on the northern islands due to golden eagle predation and on the southern island of Santa Catalina due to distemper. The original intent was only to maintain foxes in captivity until the threats to their survival had been eliminated; initial estimates were that it might take 5 years. It has taken longer to rid the islands of these threats than expected and the captive breeding program on the northern islands to produce foxes for release has not been as successful as expected. The breeding success of captive-born island foxes is very low; on the northern islands, captive-born females have produced young successfully less than 8% of the time (compared with wild-born females at 60%) (Coonan, memo 22 Feb 2005).

The poor breeding success of captive-born foxes and the likelihood that island foxes will need to be maintained and bred in captivity longer than originally projected requires a re-thinking of the original assumptions and strategy guiding island fox captive management and breeding.

As the Task Force suggests, the current island facilities appear not to be appropriate for long-term management, breeding and research. Additionally, it is clear from limited success with captive breeding of captive-born animals that there is much we still do not understand about island fox biology and reproduction. The Husbandry Manual coordinated by staff from Santa Barbara Zoo is especially useful as a guideline for current management, having been prepared from the responses to surveys of all existing facilities holding subspecies of Channel Island foxes. The Husbandry Manual, however, is clearly an evolving document and points out the lacunae in our knowledge of island fox husbandry and management. Additionally, we cannot determine from the Husbandry Manual what data exist to demonstrate that one management technique is better than another and results in greater breeding success.

The clear need for improved breeding success and our limited understanding of fox biology suggest that research in fox social and reproductive behavior as well as behavioral development should be a high priority. Most critical, of course, and highest priority, is an analysis of the biologically intrinsic, environmental, husbandry and management correlates of breeding success and the development of management recommendations that are more standardized and have more scientific analyses to back them up. For example, the Husbandry Guidelines mention the use of nearly 10 different types of enrichment items, but with no evaluation of the effects of these different items. Systematic research by fox curators and caretakers on husbandry and environmental variables and their correlation with successful reproduction will provide clearer management guidelines.

Another critical area of research concerns a determination of the best management practices for foxes pre-and post-release. Whilst some practices, e.g. reintroducing foxes in the autumn, appear to be generally accepted as “Best Practices”, we have few scientific data demonstrating the best methods for managing foxes prior to release, e.g. how much human contact is acceptable, what is the best feeding regime, what is the best social grouping, etc. Moreover, we do not know if there are individual behavioral characteristics of foxes (e.g. personality characteristics) that result in greater survivorship of certain types of foxes. Thus, there is a great need for a concerted effort to develop research protocols that will result in a set of recommendations for managing the reintroduction program for island foxes.

We have requested a new Task Force (3.5) to develop minimum standardized pre-release and post-release management and monitoring protocols for all listed subspecies of island foxes and to identify priority research that will permit the comparison of methodologies to determine the most successful pre- and post-release management.

#### **RECOMMENDATIONS:**

*Recommendation 1:* We recommend that the Land Managers, with assistance from the Captive Population TEG of the Channel Islands Fox Working Group, standardize record-keeping

protocols to ensure that caretakers collect comparable data in each facility that holds island foxes. Daily records should include, but not be restricted to, diet, feeding schedules and protocols, observed behavior, enrichment items presented, and responses of the foxes.

We will copy and distribute the Husbandry Manual and the results of the husbandry workshop held in 2003 at Santa Barbara Zoo to all managers and caretakers of island foxes. Additionally, it is important that the Captive Population TEG continue to review and update the Husbandry Manual each year to reflect new knowledge. We suggest that a captive breeding and management email group be formed to facilitate the sharing and exchange of new and existing information about the husbandry, biology, and captive management of island foxes. This forum should assemble references to all published papers on island fox biology and husbandry so that new curators and caretakers can rapidly find all existing information important for managing foxes.

*Recommendation 2:* As indicated by the Task Force (3.4), the Channel Islands captive breeding facilities are not ideal either for a long-term genetic reservoir of captive island foxes or for conducting the type of research required to determine "Best Practices" for management, husbandry and reproduction of island foxes. The RCG is developing a Technical Analysis Request to evaluate the costs and benefits of moving foxes to mainland facilities and the criteria for choosing which subspecies might benefit from a long-term mainland captive population. In the interim, we strongly recommend that three research projects be initiated immediately: 1) an evaluation of the environmental correlates of reproductive success, 2) a comparison of the social and reproductive behavior of currently successful vs. unsuccessful breeding pairs, and 3) a study of the development of mate choice in non-breeding pairs and yearlings. We will request that a Task Force immediately be charged with developing the study design for Projects 2 and 3, including doing a cost-benefit analysis of the best methods for recording data in the current island facilities and what facilities would be needed for assessing mate choice.

**ANALYSIS 3.4 REQUEST RESPONSE  
TO THE CHANNEL ISLAND FOX  
RECOVERY COORDINATION GROUP**

Date 03 February 2005

**ANALYSIS REQUEST STATEMENT**

Analyses 3.4 – Develop management and husbandry plans for each subspecies, taking into account studbook data, and results from research into best husbandry practices (pen size, social structure, mate choice, etc). The focus for research and management for each captive population will depend on the size and stability of that subspecies' wild and captive populations.

**TASK FORCE LEAD**

Marsha Sovada – USGS- Northern Prairie Wildlife Research Group - Member of the Reintroduction and Captive Population Management Expertise Groups

**CHAIR OF EXPERTISE GROUP ASSIGNED TO TASK FORCE**

Peter Siminski –The Living Desert – Chair of the Captive Population Management Expertise Group

**TASK FORCE MEMBERS**

Matt Christianson, Susan Coppelli, Devra Kleiman, Anny Ku, Stephanie Provinski, Marsha Sovada, Mitch Dennis, Kathy Kimble, Ingrid Russell, Brian Smith, Peter Dratch, Melissa Gray, Colleen Lynch, Scott Citino, Mark Willet

**EXECUTIVE SUMMARY**

The task force considers the current island facilities adequate for emergency rescue and sanctuary for wild island foxes that are under immediate critical threats from unresolved factors. The island facilities have a limited capacity for population augmentation and research. These facilities are not sufficient to serve as a redundant population to the wild populations.

The task force developed general husbandry guidelines for island fox husbandry. These guidelines assure good animal welfare and promote husbandry that would result in foxes suitable for release to the wild. These guidelines focus on island foxes that may be released to the wild. The guidelines consider foxes in captivity on the islands or on the mainland. Specific guidelines for each island were not determined.

The task force identified and prioritized research and management strategies to address known husbandry and reintroduction problems. Two areas of needed research and management action were identified. These are examination of the factors that influence breeding success and productivity, and examination of the factors that influence post-release survival. The task force recommends the following specific actions:

- analysis of mate aggression and incompatibility,
- analysis of breeding success and failure,

- evaluation of pen design to facilitate successful mate choice, and
- research and development of protocols for pre-release preparation and evaluation.

## INTRODUCTION

The Island Fox Recovery Strategy (Coonan 2003) identifies captive breeding as crucial for the recovery of island fox populations to viable levels on the northern Channel Islands. Because populations on four islands are critically low and the probability of extinction is high, to reach viable levels the populations require augmentation. At the recommendation of the Island Fox Conservation Working Group in 1999 (Coonan and Rutz 2001), a captive breeding program at Santa Catalina, San Miguel, Santa Cruz and Santa Rosa islands were developed with the primary purpose of providing captive bred foxes to supplement/restore populations of wild foxes to viable levels. Foxes captured and retained on the individual islands and the young produced in captivity were to be release into appropriate habitats on the islands once threats (e.g., eagle predation) to the population were minimized or eliminated. Because these threats to the wild population persist, management and research of the captive populations has become more critical and complex as captive populations grow in numbers, taxing the available facilities on each island.

Captive breeding was also implemented in 1998 on Santa Catalina Island when the fox population on the island's west side suffered catastrophic declines following the introduction of canine distemper (Timm et al. 2000). The east and west sides of the island are separated by a narrow isthmus and the fox population on the east side was not affected. To restore the population on the west side, foxes were bred in captivity on the east side to provide foxes for release on the west side.

Demographic modeling was used to analyze various levels of population augmentation to reach target recovery goals for fox populations on each of the islands (Roemer et al. 2001). For example, modeling suggests that when typical mortality and reproduction are assumed, supplementation of the San Miguel population (assumed wild population to be 0) with 12 foxes annually could result in about 55 foxes at five years, 130 foxes at 10 years, and 200 foxes within 15 years (Coonan 2003). But, clearly, the greatest rate of population growth could be attained by augmenting wild populations with the maximum number of foxes annually. Thus, it is beneficial for captive breeding programs to produce the maximum number of foxes possible for release.

In 2001 the Santa Barbara Zoo hosted the first Channel Island fox husbandry workshop. One of the goals of this workshop was to compile basic information for a set of husbandry standards for the island fox. These standards were primarily developed for foxes not slated for reintroduction, although components are certainly applicable for foxes to be introduced. Proceeding of this workshop can be acquired from the Santa Barbara Zoological Park ( Russell, 2001).

To guarantee adequate numbers of foxes for release programs, and to prepare individual foxes for release this task force identified management and research areas that would contribute to achieving the goals of the strategic plan. First, there is a need for standardized animal care protocols for island foxes held in captivity to insure meeting animal welfare standards and proper care of foxes operating procedures. Second, there is

a need to implement a coordinated research program to provide information for managing captive populations and preparing foxes for eventual release.

## ANALYSIS

### *Animal Husbandry Protocols*

The design of a captive facility and the development of husbandry practices within that facility depend on the goals of the facility. Types of goals that are appropriated for island foxes might be:

- Sanctuary for wild-caught foxes from current threats in the wild,
- Captive production to augment wild populations,
- Preparation and evaluation of captive foxes for release or re-release to the wild,
- Husbandry or medical health research, and/or
- A captive redundant population to the wild population.

The island facilities were developed with sanctuary and augmentation as goals (Coonan, 2003). These facilities were developed with limited capability to conduct research, make behavioral observations or the ability to evaluate the competency of the captive foxes for release. They are also insufficient to act as a population redundant to the wild population. The current facilities were developed with limited information available on island fox husbandry needs.

It is reasonable to assume that as recovery proceeds that the role of the island facilities will change. If a large mainland captive population is developed and as recovery progresses, the island facilities could shift to emergency sanctuary and release-candidate preparation and evaluation only. The mainland captive population would assume a larger role in production for augmentation, research, and as a population redundant to the wild population. The task force would expect these changes to take place gradually over several years.

The task force has developed general husbandry guidelines for island foxes based on a review of swift fox captive husbandry, our limited knowledge of island fox husbandry (Russell et al 2001), and other appropriate fox species kept in captivity. The guidelines were developed with the understanding that island foxes need to be assured good animal welfare and that they may eventually be released to the wild. It is expected that facility design and husbandry practices will change as new knowledge is gained. Specific protocols for each island facility would best be determined by the island facility managers and caretakers of those facilities with the guidance provided in the attached document and the following proposed research.

### *Research and Management*

There is a need to be adaptive in the management and research of the captive population. Information gaps are likely to emerge and should direct future research as we better understand the dynamics of the captive population. Presently, we have identified two specific areas of research that we feel are important. The first research need involves identification of factors that influence the breeding success and productivity of pairs in captivity. The captive populations have steadily increased, however, there are concerns regarding reproductive performance. Some pairs or individuals of reproductive age have

consistently failed to produce pups. Furthermore, six new pairings in 2003 (2-San Miguel, 3-Santa Rosa, 1-Santa Cruz) resulted in overt and severe male aggression toward the female foxes. In one case, the female died of the injuries sustained. There is a need for research to fill information gaps. Knowledge gained could guide management decisions to more effectively manage captive populations to generate animals for restoration to the islands.

The second research need is for development of a pre-release management strategy to ensure high survival rates and breeding success of released foxes. This could include identification of behavior characteristics in individual foxes that would enhance post-release survival or implementation of behavioral conditioning (e.g., feeding at night to encourage nocturnal rather than diurnal foraging) to improve the likelihood of successful reintroduction to the wild. The behavior of released foxes will influence their ability to survive, particularly if predation threats are not sufficiently diminished before release. Kleiman (1989) identifies six areas of behavior to consider in preparing animals for release. These involve their ability to avoid predators, acquire food, interaction appropriately with conspecifics, locate or construct shelter, travel over difficult terrain, and orientate and navigate through unfamiliar environments. Guidelines for promoting these abilities and ensuring the best chance for survival following release are critically needed. Two of these areas are particularly critical and can be addressed in the captive populations: predator avoidance and food acquisition.

## **PRESENTATION OF ALTERNATIVES**

### ***Animal Husbandry***

The guidelines for animal husbandry presented here should be considered an evolving document. We fully expect that newly gained knowledge will contribute to improvement and modification for issues such as pen design and handling of foxes. Studies may require special modification to facilities to accommodate data collection and we encourage scientists to consider costs of those modifications when planning and submitting budgets to study captive populations. Space is limited in holding facilities located on the islands; thus there is a greater probability that foxes could be moved to the mainland if threats to wild foxes persist, hindering release of captive animals. It is important to prepare for that potential scenario and identify mainland facilities that are appropriate for the foxes.

## ***Research and Management***

### ***Factors that influence breeding success and productivity***

This committee recognizes several options for research and perhaps adaptive management of the captive population. First, knowing more about best methods of pairing individuals is critical for planning a strategy to improve reproductive success and maintaining genetic diversity. Basic research that will answer questions such as 1) are unsuccessful pairings simply incompatible, 2) can compatibility be determined through observation of potential pairs held in adjacent pens, 3) if males are introduced into the female's pen, rather than a female into a male's pen when initially paired, will the male be less aggressive, 4) is failed productivity because the females are not conceptive, females are losing pregnancies, pups born dead, or pups are by parents soon after birth? Answering such questions would enable biologists to make founded decisions to manage the captive population. Behavioral observation and monitoring (e.g., den box cameras, determination of pregnancy via hormone monitoring, ultrasound) of the foxes could provide some of this information need. We recommend a coordinated effort to obtain behavioral data and monitoring of foxes at captive breeding facilities. Our committee concurs with the Mate Choice Subgroup of the Conservation Working Group in their recommendations regarding mate choice experiments to advance knowledge on fox reproductive behavior (Copy attached). Those recommendation include design and construction (or modification) of pens on one or more (we suggest two or more) captive breeding facilities that would facilitate observation of mating behavior among foxes.

### ***Factors that influence post-release survival***

The abilities to avoid predators and secure adequate food resources are two obvious criteria for survival of island foxes introduced into the wild. It is unknown if, among individual foxes, there are differences in the ability to detect and respond appropriately to predators, or if there are other behaviors that might influence vulnerability to predation threats. A beneficial trait would be an innate fear of eagles coupled with appropriate responses. The response of individual foxes to visual detection of eagles could be tested among captive foxes (wild and captive born). Although it might be unreasonable to expect success in training anti-predator behavior, if this behavior is innate differences among foxes in their response to eagles could be considered when selecting individual foxes as candidates for release. Furthermore, if differences occur, foxes less fearful of eagles might be more appropriate for transfer to the safety of mainland zoos should that management action occur.

Other behavioral traits likely would have potential to correlate with post-release survival. For example, nocturnal activity patterns rather than diurnal patterns would reduce exposure of foxes to eagles, thus improve chances of survival. It would be valuable to develop techniques to encourage such traits in the captive populations. Conditioning foxes to be active at night might be possible by providing food only at night and water in the den box continually but above ground only at night. Perhaps reducing available shade would force animals underground during the daylight. Experiments would provide insight to what might work to condition foxes to night-time foraging.

There are other potential mechanisms to prepare foxes for release such as presentation of live prey, acclimatization to release areas (soft releases), and others. The

challenge for the research community will be to thoughtfully design proposals and secure funds to meet research needs that can be addressed through observation of the captive populations.

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## Recommendations from the Mate Choice Subgroup of the Island Fox Conservation Working Group

Summary: On March 30, 2004 a teleconference orchestrated by Mr. Keith Rutz (Channel Islands National Park) was held to discuss options for increasing productivity and decreasing aggression in the Island fox Captive Breeding facilities. In addition to Mr. Rutz, Dr. Cheri Asa (St. Louis Zoo), Dr. Devra Kleiman (Smithsonian Institution), Dr. Kathy Ralls (Smithsonian Institution), and Dr. Gary Roemer (New Mexico State University) were in attendance. Dr. Roemer orchestrated a second conference call on May 4, 2004.

Recommendations: The following recommendations are categorized into two separate but equally important foci: (I) Pen Design and Mate Choice Experiments, and (II) Risk Assessment, PVA, and the Development of a Mainland Research and Breeding Facility. Within each category, recommendations are prioritized by number and include the application of various approaches/policies and the establishment of research facilities to enhance propagation and reduce aggression within the captive facilities. These recommendations should be considered urgent with implementation beginning sometime this year.

### **I. Pen Design and Mate Choice**

1. Alterations to Current Pen Designs – The current pens housing captive foxes are either L- or U-shaped and have proven adequate in many cases to allow successful breeding especially on Santa Rosa Island. Nevertheless, overt male aggression toward females recently occurred in six new pairs formed at the existing Island fox Captive Breeding Facilities (San Miguel, n = 2; Santa Rosa, n = 3; and Santa Cruz, n = 1). On San Miguel Island, a female died of the injuries sustained. This female was the last wild fox captured on San Miguel and thus, an important potential founder. The recent injuries and resulting mortalities of females suggest that modifying pens to increase “escape habitat” might lessen the potential for aggressive interactions. First, creating complete visual barriers between cages may be essential because aggression exhibited within a pair bond may happen because of cross-cage inter-male aggression. Thus, if males (and females) are interacting aggressively with foxes in neighboring cages, they may displace that pent-up aggression on their respective mate. One way to potentially reduce intra-pair aggression is to reduce contact across cages as much as possible.

Second, additional visual barriers and nesting sites within cages may provide for more “escape habitat.” It has been noted that males and females in the same cage frequently rest together regardless of their breeding success (K. Rutz, pers. obs.). This lack of difference in resting behavior may simply be a consequence of limited resting sites. If given the opportunity, members of unsuccessful pairs may opt to rest apart, this could reduce contact, lower aggression and if differences in resting behavior between unsuccessful and successful pairs occurs this could be another cue to selecting and establishing successful pairs. It should be noted, however, that additional visual barriers aimed at reducing aggression among foxes could limit observations necessary for evaluating pair bonds (see Items 2 through 4 below). Finally, it may be important to increase the size of current and future pens.

2. Design and Construction of Pens to Facilitate Mate Choice – To evaluate mate preference by foxes it is necessary to construct a pen that will facilitate observations and experiments concerning pair preferences and pair bond development. We recommend that new pens be designed at one or more island captive breeding facilities for the express purpose of evaluating pair bond behavior among foxes. By allowing individual foxes to indicate which of several individuals of the opposite sex they prefer, this facility would enable us to set up more compatible pairs less inclined to display aggressive behavior and more likely to reproduce successfully. The design should enable females and males the opportunity to interact with members of either sex, initially without direct contact to avoid injury, but to also allow direct contact between males and females. The pen design could take a variety of forms. One potential design could be similar to an octagon whereby a female or male could be introduced into a run that would allow an individual the opportunity to interact with one or more individuals of the opposite sex housed in adjacent pens (Figure 1). The pen will also have to have a blind for observation and/or video cameras arranged in such a way as to permit complete viewing of the pen area. Please note that the design we have proffered is an example, selection of a final design should consider cost and other ramifications.

3. Behavioral Profile of Successful and Unsuccessful Pairs – To evaluate the reproductive potential of new pairings it is important to identify and understand the behaviors exhibited by successfully mated pairs. Are there significant differences between the behaviors exhibited by successful vs. unsuccessful pairs? Do successful pairs spend more time together? Do they frequently rest together? Do they allogroom? To address such questions, structured behavioral observations should be implemented to develop behavioral profiles (e.g., to assess time allocated toward different behaviors). A comparison of behavioral profiles of successful and unsuccessful pairs can then be used to assist in evaluating the reproductive potential of newly formed pairs.

4. Mate Choice Experiments – Although production in the captive facility on Santa Rosa Island has been relatively high, the captive breeding facility on San Miguel has historically not produced enough pups for sustained releases (Roemer et al. 2001a). Estimates of genetic relatedness and pedigree analysis have been used to form new pairs (Gray et al. 2001), but it is clear that there is a need to devise strategies that may improve mate compatibility and increase productivity.

Once a mate choice pen has been constructed, a series of mate choice experiments should be conducted. For example, (1) “Pair tests” could be carried out where a male and female that have never met before are placed in direct contact with one another and the initial behavioral interactions recorded. These behaviors can then be compared with behavioral profiles of successful and unsuccessful pairs after they have experienced similar separations and reunions and/or (2) “Pair-wise” or “Multiple-pair tests” could be performed to assess female reaction to several males and male reaction to several females. Additional approaches also could be explored (see Mateo 2002, Roberts and Gosling 2004). Data from multiple tests of discrimination may be necessary to evaluate the mechanisms underlying kin recognition and mate choice (Mateo 2003). Data gathered from multiple discrimination tests could be compared to that collected for successful pairs and then be used along with genetic and pedigree information to suggest the most likely pairings for upcoming breeding seasons. Experimental designs for the adopted approaches will have to be rigorously developed and adaptive strategies

also should be incorporated as knowledge is gained from the experiments. These mate choice pens may also be useful for other kinds of studies (e.g., predator recognition and avoidance).

5. MHC Variation and Mate Choice – Recent research in island foxes has shown considerable variation at the Major Histocompatibility Complex (MHC) even in populations of island foxes that were previously shown to be monomorphic at highly-variable nuclear loci (Aguilar et al. 2004). The MHC has been shown to be important in kin recognition and mate choice in fish (Reusch et al. 2001), mice (Penn and Potts 1998, 1999, Potts et al. 1991) and humans (Wedekind et al. 1995) and could play a role in island fox kin recognition and sexual selection as well.

We recommend that tissue samples for known mated pairs where successful breeding has occurred in the wild (Roemer et al. 2001b) and for those in captivity (Coonan 2003) be assayed for variation at the MHC and be compared to pairs that have not bred in captivity. Such an analysis may yield valuable information that also can be incorporated with existing estimates of relatedness generated with hypervariable loci and pedigree information to suggest future pairings of captive foxes. Drs. Aguilar, Roemer and Wayne have agreed to pursue this research; both field data and tissue samples are already available.

## **II. Risk Assessment, Population Viability Analysis and the Development of a Mainland Research and Breeding Facility**

1. Risk Assessment to Address the Effect of Translocating Foxes to and from the Channel Islands - A mainland research facility would have several advantages in that additional populations of foxes would be established as a safeguard against catastrophic loss on the islands and because research can be more cost-effective given the logistics of building and staffing facilities on the islands. Before such facilities can be developed, protocols for transporting foxes to and from mainland facilities would need to be established as a safeguard against disease transmission. We highly recommend that an immediate effort be undertaken to develop such protocols in concert with 1) existing expertise in fox disease pathology, 2) veterinary expertise from individuals that have developed such protocols for other species and reintroduction programs, and 3) within an inclusive risk-assessment scenario that considers disease risk, and other risks such as the possibility of catastrophic loss and extinction in small populations due to demographic uncertainty. Such an approach is urgently needed.

2. Mainland Research and Breeding Facility – Because of the difficulty of experimentation, continuous observation of captive foxes, and the associated logistical difficulties and expense on the islands, we highly recommend that one or more mainland research and breeding facility be established. These facilities could be used to explore island fox 1) sociobiology (mating, pair bond and kit rearing patterns), 2) reproductive biology (estrus cycle, sperm viability, etc.) and 3) disease relationships. Conditioning experiments (to avoid predation) could also be more easily conducted in a controlled environment. The need for such a facility is paramount but cannot proceed without accomplishing the risk assessment. One or more existing captive breeding facilities willing to commit to island fox breeding and research or organizations willing to develop such a facility need to be identified.

3. Population Viability Analysis to Address the Persistence of the Captive Colonies – Both the San Miguel and Santa Rosa facilities have produced pups that have resulted in a highly skewed

sex ratio that limits the number of pairings (Coonan and Rutz 2003). Prior to the releases of captive animals in 2003, there were 11 unpaired males on San Miguel Island and 19 unpaired females on Santa Rosa Island. Demographic modeling simulated population recovery by releasing 6 to 12 foxes either annually or bi-annually for 10 to 20 years (Roemer et al. 2001a). This simulation suggested that an extirpated population could be recovered but that only the highest release scenarios (i.e., releasing 6 to 12 foxes annually) would allow the population to reach a target population size of 200 animals within 50 years or less (Figure 2). This simulation assumed an equal sex ratio and that all captive individuals released survived, paired and bred on schedules mimicking the wild populations before the recorded population declines. Disease and predation, both factors implicated in the recent population declines, were not included in the analysis. Thus, if the simulations were close to reality, each facility would have to produce 3 to 6 viable pairs of foxes each year to start recovering the extirpated populations.

The aforementioned simulation raises an important question: Can the captive facilities produce enough pairs to maintain the size of the captive facilities (ultimately 20 breeding pairs, which has never been realized) and at the same time produce enough pairs to sustain long-term releases? The recent skew in sex ratio suggests that the production within the captive facilities may not be sufficient to accomplish these tasks. A new simulation using current reproductive data from the captive colonies may help to address this issue. Recent models that optimize approaches and consider cost may be fruitful (Haight et al. 2002, 2004). In sum, additional population viability analyses need to be conducted to address the long-term persistence of the captive facilities and their potential to reestablish extirpated populations.

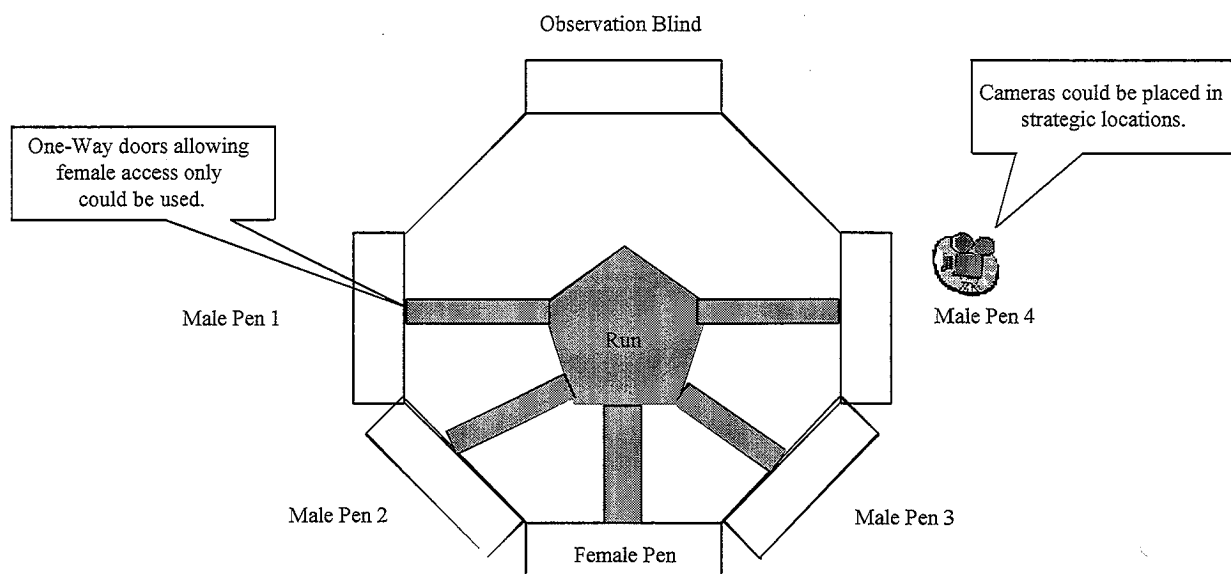


Figure 1. Example of a potential pen design that could be used for assessing mate choice in island foxes. In this design, a female has access to a run that connects her to 4 different pens housing different males. The time a female spends inspecting and interacting with particular males and the behaviors the pair exhibit may be used to indicate female preference.

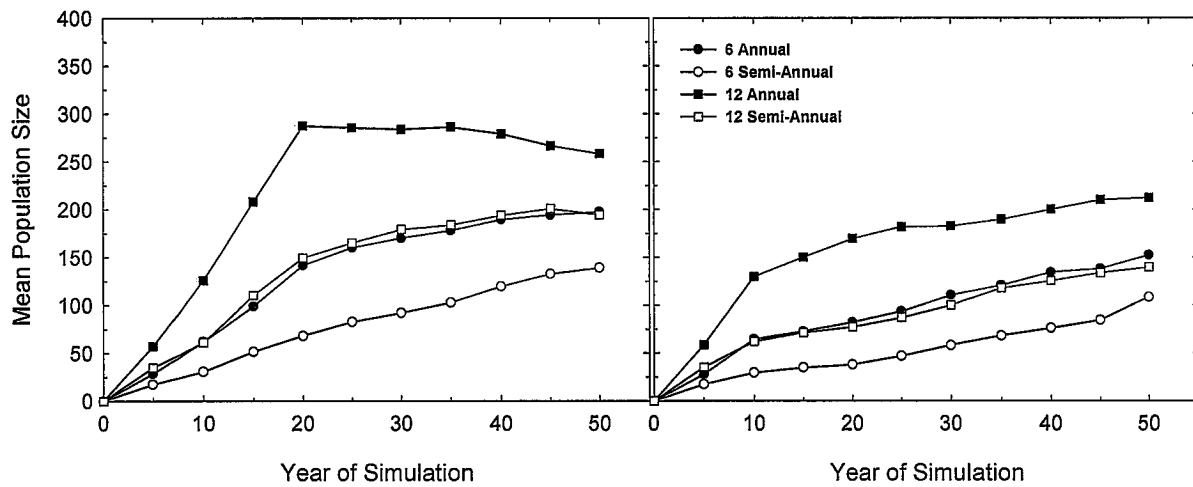


Figure 2. Population trajectories for a simulated San Miguel fox population initiated with captive-born animals and subsequently supplemented with 6 or 12 individuals (equal sex ratio), annually or semi-annually, for a period of twenty years (left panel) or ten years (right panel).

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## **HUSBANDRY AND MANAGEMENT GUIDELINES FOR ISLAND FOXES TO BE RE-INTRODUCED TO THE WILD**

### **INTRODUCTION**

In June 2004, the Island Fox Integrated Recovery Implementation Team met. At this meeting, a task force was created with the charge of developing a management and husbandry plan for captive foxes. Husbandry recommendations for the permanent captive mainland population of foxes have already been compiled at recent husbandry workshops held at the Santa Barbara Zoological Gardens. Copies of these guidelines can be provided upon request to the Santa Barbara Zoo.

The following husbandry and management guidelines will focus on island foxes that are part of the reintroduction program. These guidelines were developed from information compiled from surveys distributed to all current captive fox locations on the islands. The following islands returned completed surveys: San Nicolas, San Miguel, Santa Rosa, and Santa Cruz. Guidelines specific to subspecies are not deemed necessary at this time. Responses from the surveys indicated there were no special considerations needed for individual subspecies.

These guidelines have been written under the assumption that foxes identified for reintroduction to the wild may be held in a captive setting, at least temporarily, on their native islands or on the mainland. Husbandry and management recommendations have been written to include three different scenarios. The "Islands" scenario is for foxes that are held in captivity on their native island and identified for release. The "Mainland <sup>A</sup>" scenario is for foxes that are housed in captivity on the mainland, identified for release on their native island, and are provided a pre-release acclimation period on the island prior to release. The "Mainland <sup>B</sup>" scenario is for foxes that are housed in captivity on the mainland, identified for release on their native island but are not provided a pre-release acclimation period on the island prior to release.

Foxes identified for release may require alternative husbandry and management guidelines. These training-for-release guidelines will be developed as necessary.

### **HUSBANDRY AND MANAGEMENT RECOMMENDATIONS**

#### **Abiotic Environmental Variables**

Temperature:

##### Islands

<sup>A</sup> Guidelines for foxes that are housed in captivity on the mainland, identified for release on their native island, and are provided a pre-release acclimation period on the island prior to release.

<sup>B</sup> Guidelines for foxes that are housed in captivity on the mainland, identified for release on their native island but are not provided a pre-release acclimation period on the island prior to release.

Island foxes housed on their native islands should be kept within normal island temperature ranges. Supplemental heating or cooling should not be necessary.

#### Mainland<sup>A</sup>

Island foxes housed on the mainland should be kept between 32° and 100° F (0-38 C). (This range incorporates all Channel Island climates.) Although island foxes are able to withstand occasional extremes of temperature, supplemental heating or cooling may be necessary if extreme temperatures persist.

#### Mainland<sup>B</sup>

Island foxes housed on the mainland should be kept within the normal temperature range for their native island. Supplemental heating or cooling may be necessary to maintain these conditions.

#### Humidity:

Island foxes do not have specific humidity requirements.

#### Illumination:

Natural light and light cycles are recommended. For island foxes housed indoors, a day/night cycle of 12 hours light/12 hours dark, or one that matches seasonal changes is advised.

#### Space

A variety of pen sizes and shapes have been used and proven successful for breeding of island foxes.

Pens currently used to house island foxes range from 120 – 1000 ft<sup>2</sup>, though larger pens may be used. Standard 2"x2" chain link or smaller is recommended. If flexible netting (i.e. woven mesh) is used for containment, 1" openings are recommended especially for containment of kits. Ground skirting or underground concrete curbing are necessary to prevent foxes from digging out of pens. Pens should be topped with a material containing openings no larger than 2"x2".

Pen shapes currently used include rectangular, L-shaped, U-shaped, and Z-shaped.

#### Inter-individual distances

It is recommended that foxes be housed in male-female pairs or same sex pairs. A buffer space is necessary between pairs of foxes. It has been observed that fox pairs housed next to each other, with a common divider between them, will fight. Currently pens are separated by at least 6 feet. This distance between pairs has proven successful for breeding. A minimum distance between pairs where island foxes do not fight or become stressed and provides a successful breeding environment has yet to be determined.

#### Temporary Separation

<sup>A</sup> Guidelines for foxes that are housed in captivity on the mainland, identified for release on their native island, and are provided a pre-release acclimation period on the island prior to release.

<sup>B</sup> Guidelines for foxes that are housed in captivity on the mainland, identified for release on their native island but are not provided a pre-release acclimation period on the island prior to release.

Individuals may need to be separated from other island foxes for an extended period of time and for a variety of reasons. A means of separating and isolating individuals should be available. No accounts of any behavioral challenges have been noted for foxes housed as singles.

Introduction and reintroduction of individuals are typically unproblematic. A protected, mesh-to-mesh visitation opportunity should be provided in order to assess individuals' behavior toward each other before physical contact is allowed. Introduction/reintroduction should be monitored for signs of aggression, displacement, stress, or other behaviors that indicate the two individuals may not do well sharing the same living space.

Females do not need to be isolated prior to or post parturition unless pen mates exhibit behavior that either interferes in the female's ability to care for her young or places the kits' health in danger.

### Furnishings

Island foxes are good climbers by nature. Therefore, climbing and above ground resting opportunities should be provided. Items such as plywood, fence panels, logs, trees, PVC pipes, hammocks, and shelves have been provided in the past and utilized by foxes.

Island foxes in the wild are regularly found in dens. Therefore, dens or similar ground level or sub-ground level private resting areas should be provided. Items such as vegetation, teepees, deadfall piles, den/nest boxes, and PVC pipes have been provided in the past and utilized by foxes.

At least one den/nest box should be provided in each pen. Providing multiple den areas allows animals to choose a den site that is most comfortable for them. A variety of den/nest boxes have been provided in the past and all have proven successful for breeding. Currently used boxes range from 30"x42", 30" tall and subdivided into two chambers to 24"x34", 14" tall and subdivided into three chambers including an entry. Some box roofs have overhangs, some boxes are partially buried, and some boxes have multiple entrances. There are some island foxes that do not use boxes provided and prefer to dig their own natural dens. In general, box design does not appear to affect breeding behavior or parturition and each individual fox seems to have its own preference for den sites.

### Shelter/shade

Shelter and shade from the elements should be provided at all times. Elements that should be considered when creating sheltered areas include rain, wind, and sun.

### Visual, Acoustic, and Olfactory Barriers

<sup>A</sup> Guidelines for foxes that are housed in captivity on the mainland, identified for release on their native island, and are provided a pre-release acclimation period on the island prior to release.

<sup>B</sup> Guidelines for foxes that are housed in captivity on the mainland, identified for release on their native island but are not provided a pre-release acclimation period on the island prior to release.

Visual barriers between island foxes within close proximity have proven to be ineffective in reducing stress or aggression between pairs. In situations where foxes have appropriate inter-individual distance between them, visual barriers are not necessary but may have some benefit in reducing stress.

Acoustic and olfactory barriers, other than large inter-individual distance, have not been used with island foxes.

#### Substrates and bedding materials

Natural soil substrate is recommended for island fox enclosures. Other substrates and bedding materials have been provided; wood shavings, bark chips, mulch, straw, hay, and sand.

Providing bedding material in den/nest boxes is not necessary for pregnant females and may discourage use of the box if the bedding is foreign or disliked by the individual. If bedding is provided, favored bedding types should be identified and used prior to and post parturition.

#### Enclosure variation

Due to the inquisitive nature of the island fox, it is recommended that pen furniture (i.e. perching, resting platforms, etc.) be rearranged on occasion to provide foxes with an opportunity to explore a “new space”. Furniture may be rotated between pens housing healthy foxes to provide stimulation and encourage natural behaviors.

Care should be taken not to disturb favorite den locations, especially prior to and post parturition.

#### Enclosure Cleaning

It is recommended that pens be cleaned at least 3 times weekly although once daily is preferred. At these times, removal of fecal material, left over food, old enrichment items, and foreign debris should be removed. Hard surfaces used for feeding or those that have been urinated upon, etc. should be disinfected as needed.

During breeding season, pen cleaning may be decreased to at least one time weekly. More frequent pen cleaning during this time does not seem to affect how the foxes care for their kits as long as the den site is not disturbed.

#### Containment

A variety of barriers may be used to contain island foxes including chain link fencing, stainless steel woven mesh, wire mesh, and solid walls of brick, wood, etc. Barriers should be free of protrusions that could cause injury or provide unwanted climbing opportunities.

A top on the enclosure is essential for containment of foxes. Enclosures with either no top or just an overhang (90 degree angle and 18” wide) have not provided adequate containment. It is recommended that enclosures have a

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complete and secure ceiling made of any of the materials listed above to ensure containment.

Either an underground curb or ground skirt is essential to prevent foxes from digging out of the enclosure.

Special consideration is necessary for containment of kits. Kits have been observed fitting through 2"x2" mesh. Therefore, all openings and gaps larger than 1.5" should be covered with shade cloth, hardware cloth, a smaller mesh material. Openings no larger than 1"x1" are recommended for enclosures containing kits.

## **Biotic Variables**

### **Water**

Clean, fresh water should be made available at all times. Water bowls should be disinfected regularly to prevent algae or bacterial build up.

### **Food**

It is recommended that island foxes be fed daily and as close to dusk as possible to mimic their naturally nocturnal habits.

### **Food presentation**

Food may be presented in a bowl, scattered throughout the pen or placed in enrichment feeders. At least one feeding location should be available for each fox within the pen and feeding locations should be separated as much as possible to avoid allowing one individual to dominate all feeding locations

#### Islands & Mainland<sup>B</sup>

Whilst special effort to keep foxes from associating food with keepers does not seem to affect release success, hand feeding is not recommended.

#### Mainland<sup>A</sup>

Hand feeding of certain food items may be beneficial to prevent overfeeding and ensure even distribution of favorite items or medications. Hand-feeding should be discontinued once the fox reaches its training-for-release period.

### **Enrichment**

Novel food items may be used as enrichment as well as live insects or other whole prey items. The regular diet may be used in conjunction with non-food enrichment.

Non-food enrichment items that may be provided include: scents (baking spices, perfumes, catnip, etc.), vegetation/browse (fresh herbs, trimmings from non-toxic plants that are not already inside the enclosure, pine cones, etc.), puzzle feeders, Kong toys, PVC tubing, brown paper bags, cardboard boxes, socks, paper towel rolls, etc.

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<sup>B</sup> Guidelines for foxes that are housed in captivity on the mainland, identified for release on their native island but are not provided a pre-release acclimation period on the island prior to release.

Caretakers should observe animals when they are given new enrichment items to ensure they are not interacting with them in an unsafe manner. New enrichment ideas should be approved by a veterinarian prior to being given to animals.

## **Social Considerations**

### **Group size and composition**

Island foxes have been housed as singles and pairs of; 1.1, 0.2, or 2.0 (either siblings or at least one castrated male). It is recommended that pairs of 1.1 be maintained as much as possible and that, because of space availability challenges, animals housed as singles be limited.

Groupings that have not been successful in the past include; 1.2, 2.2 and 0.4. In these situations aggression took place between individuals and separation of the group was necessary. Groupings of 0.3 have been successful in one instance.

### **Human-Animal Interactions**

Island foxes tend to be very docile by nature and adapt to human presence easily. Consistency in husbandry practices allows for management with reduced stress to the foxes.

#### Islands and Mainland<sup>B</sup>

Interaction between keepers and the foxes should be limited. It is recommended that handling of the foxes be limited to emergencies or annual examinations only. The amount of time keepers spend in and around the pens should be kept to a minimum and it is recommended that keepers do not speak to the foxes and that conversations while around the foxes be kept to a minimum.

#### Mainland<sup>A</sup>

While following the recommendations listed for Islands and Mainland<sup>B</sup> is acceptable, this level of restricted interaction is not necessary for these foxes. Interactions will be more restricted once the fox reaches its training-for-release period.

## **Nutrition**

### **Diet**

There are a variety of diets currently fed to island foxes. They all use dog kibble as the main staple with fruits, vegetables, nuts, and/or whole prey as supplements. Generally, each fox receives 60-70g of dog kibble daily. Various fruits, vegetables, and nuts are added to the diet as well as whole prey items such as small birds, eggs (raw or hardboiled), mice, and insects.

Diet amounts should be modified based on the health, weight, and body condition of each individual fox.

Amounts of whole prey diet may increase during training-for-release period.

## **Medical management**

### **Quarantine and Hospitalization**

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Information regarding quarantine and hospitalization is required from the Veterinary Group of the RCG before recommendations can be made.

#### Preventative medicine

Information regarding preventative medicine is required from the Veterinary Group of the RCG before recommendations can be made.

#### Capture and Restraint Techniques

It is recommended that island foxes be captured and restrained using personal protective equipment. Capture techniques that have been effective with island foxes include: trapping in live trap or kennel, netting, and free-hand grabbing with gloved hands.

Grabbing by the scruff seems to be the easiest and most effective method of restraint. Wrapping in a towel is another restraint method that has been successful. It is recommended that island foxes be muzzled if prolonged restraint is necessary. Covering the eyes with a blind may aid in calming a fox during prolonged restraints.

#### Immobilization

Information regarding immobilization is necessary from the Veterinary Group of the RCG before recommendations can be made.

#### Pathology Protocols

Information regarding pathology protocols is necessary from the Veterinary Group of the RCG before recommendations can be made.

### **Reproduction**

#### Seasonality of Reproduction and Development

Island foxes reproduce once annually and are primarily monogamous. Mating usually occurs in February.

Gestation period is 50-53 days.

Young are sexually mature at 10 months of age though very few yearling foxes tend to breed.

#### Hormonal Tracking as a Mechanism for Identifying Reproductive State

Endocrine assays have been completed on fecal samples from San Miguel Island for 2000 and 2001 breeding seasons. Based on sustained increase in progesterone as an indicator of ovulation, it appears that these females are induced ovulators. Ovulation only occurred for those females housed with males. Cortisol levels, a hormone associated with stress, were not related to the occurrence of ovulations.

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These results are significant because all canids studied to date have been shown to ovulate spontaneously, with ovulation followed by an obligate pseudopregnancy indistinguishable hormonally from pregnancy. In contrast, felids are induced ovulators.

#### Introduction and/or Separation of Males

Males should not be separated from females prior to or post parturition unless the male is exhibiting behavior that either interferes in the female's ability to care for her young or places the kits' or dam health in danger.

#### Parturition facilities

Island foxes have been observed utilizing a variety of man-made den boxes as well as digging their own dens. It is recommended that at least one den area be available in order to reduce stress. Providing multiple den areas allows animals to choose a den site that is most comfortable for them.

A variety of den/nest boxes have been provided in the past and proven successful for breeding. Currently used boxes range from 30"x42", 30" tall and subdivided into two chambers to 24"x34", 14" tall and subdivided into three chambers including an entry. Some box roofs have overhangs, some boxes are partially buried, and some boxes have multiple entrances. There are some island foxes that do not use boxes that have been provided and prefer to dig their own natural dens. In general, box design does not appear to affect denning behavior and each individual fox seems to have its own preference for den sites.

#### Hand-rearing protocols

Information regarding hand-rearing protocols is necessary from the Veterinary Group of the RCG before recommendations can be made.

#### Contraception

Castration is the only permanent contraceptive method currently in use for island foxes.

There is one case of a contraceptive implant being used on a female member of the permanent captive mainland population.

### **Behavior Management**

#### Training

Training for routine husbandry and medical purposes is a valuable tool that can aid in the management and husbandry of the island fox. Foxes that are part of the permanent captive mainland population have been trained behaviors such as targeting, stationing, stepping onto a scale, entering a crate or Have-a-Heart trap, and desensitizing to tactile contact behind the head for scruffing.

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### Islands and Mainland<sup>B</sup>

Due to the routine and frequent contact necessary for behaviors to be trained, it is not recommended that training of foxes identified for reintroduction take place.

### Mainland<sup>A</sup>

While following the recommendations listed for Islands and Mainland<sup>B</sup> is acceptable, it is recommended that the training of behaviors such as crate training, scale training, and targeting be considered in order to provide better husbandry and medical care for these individuals. Training should be discontinued once individuals reach the training-for-release period.

### Training-for-release

Once individuals have been identified as candidates for reintroduction to the wild, it is recommended that a training period take place which will aid in successful release. Specifics regarding the timing and length of this training-for-release period have not yet been determined. These guidelines may not have direct affect on the release success rate of the foxes however, they are recommended in order to give individuals the best possible chance at a successful reintroduction.

Keeper/fox interaction: All handling of the individuals should be discontinued except for emergency medical care. The amount of time keepers spend in and around the pen should be kept to a minimum and conversation with or around foxes should be discontinued.

Food: It is recommended that the diet should be modified to mimic what foxes will find in the wild. The feeding of live prey (mice and insects) should be increased to encourage hunting behavior and other diet items should be scattered regularly in order to encourage foraging behavior.

Socialization: It is recommended that individuals, especially young foxes removed from parents, be socialized with the other individuals identified for release within the same area and time period.

Trap conditioning: Individuals should be fed part of their diet inside live traps used for recapture. These traps should be locked open allowing foxes to come and go freely. This will condition the foxes to check these traps for food, allowing easier recapture if/when necessary.

Guidelines may be added as more is learned about what challenges reintroduced foxes face upon release and why some reintroductions are not successful.

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